REPORT RESUMES

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ADJUSTMENT, MAINTENANCE, AND REPAIR OF TILLAGE, PLANTING,
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THE PURPOSE OF THIS GUIDE IS TO HELP TEACHERS PREPARE POSTSECONDARY-LEVEL STUDENTS FOR THE AGRICULTURAL MACHINERY SERVICE OCCUPATIONS AS PARTS MEN, MECHANICS, MECHANIC'S HELPERS, AND SERVICE SUPERVISORS. IT WAS DESIGNED BY A NATIONAL TASK FORCE ON THE BASIS OF RESEARCH FROM STATE STUDIES. THE MAJOR OBJECTIVE IS TO DEVELOP (1) STUDENT UNDERSTANDING OF TILLAGE, PLANTING, FERTILIZING, AND SPRAYING MACHINERY, AND (2) STUDENT ABILITY TO ADJUST, REPAIR, AND MAINTAIN THESE MACHINES. SUGGESTIONS FOR INTRODUCTION OF THE MODULE ARE GIVEN. UNIT AREAS COVER--(1) OPERATOR AND SERVICE MANUALS, (2) SOIL TILLAGE, (3) LUBRICATION, (4) TILLAGE, SECONDARY TILLAGE, CULTIVATING, CROP PLANTING, AND FERTILIZER APPLICATING MACHINES, (5) SPRAYERS, AND (6) MACHINERY PAINTING. EACH UNIT AREA INCLUDES SUGGESTED SUBJECT MATTER, TEACHING-LEARNING ACTIVITIES, INSTRUCTIONAL MATERIALS, AND REFERENCES. CRITERIA FOR EVALUATING EDUCATIONAL OUTCOMES ARE LISTED. THE COURSE IS SCHEDULED FOR 94 HOURS OF CLASS INSTRUCTION, 188 HOURS OF LABORATORY EXPERIENCE, AND 142 HOURS OF OCCUPATIONAL EXPERIENCE. TEACHERS SHOULD HAVE EXPERIENCE WITH AGRICULTURAL MACHINERY. STUDENTS SHOULD HAVE MECHANICAL APTITUDE, A HIGH SCHOOL BACKGROUND, AND AN OCCUPATIONAL GOAL IN AGRICULTURAL MACHINERY. THIS DOCUMENT IS ALSO AVAILABLE FOR A LIMITED PERIOD AS PART OF A SET (VT 000 488 THROUGH VT 000 504) FROM THE CENTER FOR VOCATIONAL AND TECHNICAL EDUCATION, THE OHIO STATE UNIVERSITY, 980 KINNEAR ROAD, COLUMBUS, OHIO 43212, FOR $7.50 PER SET. (JM)

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ADJUSTMENT, MAINTENANCE, AND REPAIR OF

TILLAGE, PLANTING, SPRAYING, & FERTILIZING MACHINERY

One of Sixteen Modules in the Course Preparing for Entry in

AGRICULTURAL MACHINERY - SERVICE OCCUPATIONS

Module No. 10

The Center for Research and Leadership Development
in Vocational and Technical Education

The Ohio State University
980 Kinnear Road
Columbus, Ohio, 43212

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MEMORANDUM

TO: The ERIC Clearinghouse on Vocational and Technical Education
The Ohio State University
980 Kinnear Road
Columbus, Ohio 43212

FROM: (Person) James W. Hensel (Agency) The Center for Vocational and Technical Education

(Address) 980 Kinnear Road, Columbus, Ohio 43212

DATE: August 4, 1967

RE: (Author, Title, Publisher, Date) Module No. 10, "Adjustment, Maintenance, and Repair of Tillage, Planting, Spraying, and Fertilizing Machinery," The Center for Vocational and Technical Education, August, 1965.

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Source (agency)
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ADJUSTMENT, MAINTENANCE, AND REPAIR OF TILLAGE, PLANTING, SPRAYING, AND FERTILIZING MACHINERY

TABLE OF CONTENTS

Page

Suggestions for Introducing the Module 1

Competencies to be Developed

I. To understand how to use operator's and service manuals when adjusting, maintaining, and repairing agricultural machinery 2

II. To understand the relationship of soil tillage methods to the soil 5

III. To select and use proper lubricants for agricultural machines 9

IV. To (1) identify types and parts of primary soil tillage machines and understand their functions and to (2) adjust and repair these machines 9

V. To (1) identify the parts and types of secondary soil tillage machines and understand their functions and to (2) adjust, repair and lubricate these machines 19

VI. To (1) identify the parts and types of cultivating machines and understand their functions and to (2) adjust and repair these machines 28

VII. To (1) identify the parts and types of crop planting machines and understand their functions and to (2) adjust and repair these machines 34

VII. To(1) identify the parts and types of sprayers and understand how they function and to (2) adjust and repair these machines 46

IX. To (1) identify the parts of fertilizer applicating machines and how they function and (2) adjust and repair these machines 65

X. To prepare and paint tillage, planting, spraying and fertilizing machines after they have been repaired 81

Suggestions for Evaluating Educational Outcomes of the Module 81

Sources of Suggested Instructional Materials and References 81

ADJUSTMENT, MAINTENANCE, AND REPAIR OF TILLAGE, PLANTING, SPRAYING, AND FERTILIZING MACHINERY

Major Teaching Objective

To (1) understand tillage, planting, fertilizing, and spraying machinery and their parts, and (2) the ability to adjust, repair, and maintain these machines.

Suggested Time Allotment

At School		
Class instruction	94 hours	
Laboratory experience	188 hours	
Total at school		282 hours
Occupational experience		142 hours
Total for module		424 hours

Suggestions for Introducing the Module

One job activity of mechanic's helpers and mechanics is adjusting, repairing, and servicing agricultural soil tillage, crop planting, fertilizing and crop spraying machines, both in the service department of the local agricultural machinery dealership and in the farmer's field. These employees, as well as the parts man, must know the types of these machines, their functions (including how they work in relation to a particular type of soil and crop), and their repair and maintenance.

Because of the diversity among machines used in various parts of the country, that serve the same purpose and the design differences developed by the major line agricultural machinery manufacturers, the operator's and service manuals should be used as the basic references for this module. All adjustments and repairs should be made according to specifications and procedures outlined in these manuals. The information in each competency provides the necessary background to make these adjustments and repairs.

The following techniques should be used to create interest in the module:

1. Locate machines in the community that are out of adjustment and in need of repair. Take students on a tour of the farms where they are, and demonstrate operation of these machines. Have students attempt to identify what part or parts are out of adjustment and how they should be properly adjusted.

2. Place parts from several machines around the classroom and have students attempt to identify them.

3. Place a relatively simple tillage machine before the class that is completely out of adjustment and in need of a number of repairs. Have each student attempt to diagnose what repairs and adjustments need to be made on the machine.

Competencies to be Developed

I. To understand how to use operator's and service manuals when adjusting, maintaining, and repairing agricultural machinery

Teacher Preparation

Subject Matter Content

For each machine that an agricultural machinery manufacturer builds, he develops and supplies the purchaser with an operator's manual that gives information concerning the following:

1. Machine specifications
2. Lubrication
3. Operation
4. Adjustment
5. Trouble shooting
6. Attachments
7. Setting-up instructions
8. A description of the machine, the function it is to perform, and design to perform this function

The specifications given for a particular machine vary among the major line agricultural machinery manufacturers, but generally include the following information:

1. Type of machine
   (Example--pull-type, self-propelled, mounted)
2. Weight, length, and width of machine
3. Lifting controls

4. Dimensions of moving parts

5. Safety clutches

6. Number and types of bearings

Proper lubrication is essential to long life and trouble-free operation of the machine. The following information is provided concerning lubrication of each machine.

1. Intervals at which lubricants should be applied

2. Recommended oils and greases to be used

3. Pictures and diagrams showing grease fittings

4. Pictures and diagrams showing the location of pre-lubricated sealed-type ball bearings and oil-less plain bearings

When servicing a machine, lubrication procedures should be studied thoroughly and followed carefully.

To make any adjustment on an agricultural machine, a mechanic or mechanic's helper must understand thoroughly the operation of each part of the machine. This information is given in the operator's manual in the section entitled "operation," which provides such information as

1. A description of how the machine is designed to work

2. The source of power and how the machine is attached to it

3. An identification of the processes the machine is designed to carry out and how the machine performs these functions

4. Maximum and minimum speeds at which the machine is designed to perform

5. An identification of each part in the machine and a description of how each part operates

6. Information to be used when servicing each machine part

Closely associated with the operation of an agricultural machine and of equal importance is proper adjustment, which is also covered in detail in the operator's manual. It should be thoroughly understood by the person making adjustments on machines in the agricultural machinery dealership. The adjustments to be made on a machine are presented and described in the same manner as are the items under the section entitled "operation."

In the trouble shooting section of the operator's manual, problems that may develop as a result of improper adjustment are identified and remedies suggested.

The agricultural machinery manufacturer develops at the same time, the operator's manual for the purchaser to use, and a service manual for the local agricultural machinery dealership to use. This manual describes in detail the disassembly, inspection, repair, and reassembly procedures to follow in making repairs on the machine. When repairing a machine, the procedures outlined in this manual must be carefully followed in order to insure proper and efficient repairing of the machine.

Suggested Teaching-Learning Activities

1. Demonstrate the use of the operator's and service manuals in making adjustments and repairs on an agricultural machine.

2. Have students lubricate, adjust, and make minor repairs on several comparatively simple (disk plow, row-crop planter) agricultural machines using the operator's and service manuals as guides. Emphasize proper use of these manuals at all times.

3. Have a lubrication specialist from a major line oil company speak on and demonstrate use of oils and greases on agricultural machinery.

Suggested Instructional Materials and References

Instructional materials

1. Operator's manuals

2. Service manuals

3. Machines needing adjusting and repairing

References

S*1. Operator's manuals

2. Service manuals

"The symbol T (teacher) or S (student) denotes those references designed especially for the teacher or for the student.

II. To understand the relationship of soil tillage methods to the soil

Teacher Preparation

Subject Matter Content

The primary function of all tillage machinery is to pulverize, aerate, and loosen the soil in preparation for planting a crop. In addition, soil tillage machines level and smooth fields, compact the top soil, and kill weeds that have started to grow before the crop is planted.

The degree to which these activities are performed on the soil and tillage machines that are selected to perform these activities is dependent on several factors.

1. Soil type
2. Erosiveness of the soil
3. Moisture availability during the growing season
4. Crops to be planted

The type of soil influences greatly the type of tillage treatment necessary to develop a well-pulverized seedbed that will produce a high-yielding crop. Soils are grouped on the following basis:

1. Sandy
2. Sandy loam
3. Loam
4. Silt loam

5. Clay loam
6. Clay
7. Heavy clay

The amount and depth of tillage necessary to prepare a good, firm seedbed varies according to the soil type. Because of the coarse texture of sandy soils, less tillage is required to loosen and aerate the soil, and machines that penetrate the soil at comparatively shallow depths are used. On heavy, compactable soils, such as clay or clay loam, more extensive tillage is required to develop a good, firm, permeable seedbed; and machines that penetrate the soil at a depth of 6" or more are used.

Another factor closely associated with the type of soil which also places limitations on the method and extent of tillage, is the susceptibility of the soil to erosion.

Two elements are responsible for causing soil erosion.

1. Wind
2. Rain

Soils that are susceptible to erosion due to high winds and rain require different tillage practices than soils in areas not so susceptible to these hazards. In areas where erosion by wind is a problem, farmers stir the subsurface avidly turning under the top soil as much as possible. In areas where erosion by rainfall is a problem, farmers turn the soil as deeply as possible to increase the permeability of the soil.

The major elements determining the physical condition and productivity of the soil are texture and structure of the soil, which tillage practices break down, thus making the soil more susceptible to erosion. This fact is illustrated in the following table.

Surface Condition	Runoff Percent	Erosion per Acre Ton
Surface fine and moist	75	12
Surface fine and dry	66	7
Surface cloddy	26	2.4

In many areas of low annual rainfall, conservation of soil moisture is of utmost importance in avoiding crop failure. Here tillage of the soil must be held at a minimum to avoid undue moisture losses. In areas where adequate rainfall prevails, the soil must be thoroughly pulverized to absorb rainfall and retain moisture for crops. In these areas unplowed soil loses most of the rainfall by runoff. Usually in these areas the humidity is so high that it is necessary to plow deep enough to bury insects and plant diseases that build up in crop residue on top of the soil.

The crop to be planted also influences the soil tillage methods to be used. Some crops need a firm, deep seedbed to develop the root system needed for maximum growth; whereas others do well in a shallow seedbed. Pulverizing the soil aerates it and enhances the activity of microorganisms and bacteria, causing rapid oxidation and decay of crop residues. Stirring the soil also aids in the nitrification and liberation of plant nutrients within the soil. The effects of various tillage practices on crop growth is pointed out in the following tables.

Table 1 - Effect of tillage treatments on corn yield, stand, height

Tillage treatment	Yield 14-year	Plants (7-year average	Height (10-year average)
	Bu.	Hundreds	In.
1. Standard plow	53.4	117	60.6
2. Prairie breaker	54.5	114	57.4
3. Rotary tillage	46.9	107	56.0
4. Surface and sub-surface tillage	44.7	95	50.5
5. Surface tillage only	40.2	92	50.4
6. Standard plow plus mulch	54.9	129	63.2

Table 2 - The effect of tillage treatments on wheat and hay yields.

Tillage treatment	Yields per Acre Wheat 9-year average		Hay* 3-year Average
	Stalks removed bu.	Stalks left bu.	lb.
1. Standard plow	27.2	21.6	3,870
2. Prairie breaker	28.6	22.9	3,870
3. Rotary tillage	26.7	24.6	3,890
4. Surface and sub-surface tillage	23.9	23.0	4,210
5. Surface tillage only	23.8	21.7	3,840
6. Standard plow plus mulch	16.8	11.8	3,830
Average	24.5	20.9	.....

*First cutting only.

Source - Ohio Agricultural Experiment Station Research Circular #30.

Suggested Teaching-Learning Activities

1. Have the local soil conservation specialist speak to the class on the relationship of soil tillage methods to the soil.

2. Take a field trip to fields in the community affected by soil erosion problems. Stress the relationship of these problems to the tillage methods applied to the soil.

3. Bring soil samples to class and have students learn to identify them.

4. Take a plow or any other soil tillage machine to fields with different soil types and affected by different climatic conditions. Have students observe how the machines work in each field.

5. Have students select a field in the community and trace the tillage practice on that field. Have students note the condition of the field in terms of erosion and soil structure breakdown and relate these conditions to the tillage histroy of the field.

Suggested Instructional Materials and References

Instructional material

Soil samples of each type identified in the subject matter content

Reference

Profitable Soil Management, pp. 195-309.

III. To select and use proper lubricants for agricultural machines

Teacher Preparation

Subject Matter Content

If the person being taught this module has not been taught the competency on understanding agricultural machinery lubrication included in the module on "Agricultural Machinery Assembly and Lubrication," he should be taught that competency at this time.

IV. To (1) identify types and parts of primary soil tillage machines and understand their functions and to (2) adjust and repair these machines

Teacher Preparation

Subject Matter Content

Machines that are used to break and loosen the soil for a depth of 6 to 36 inches to prepare a suitable seedbed are primary tillage machinery. These machines are designed to carry out the following functions:

1. Create a deep seedbed physically, chemically, and biologically fitted to the growth of crops.

2. Add humus and fertility to the soil by covering and burying crop residues so they can be incorporated into the soil.
3. Prevent and destroy weeds or other unwanted vegetation
4. Leave the soil so that air will circulate through it freely
5. Leave the soil in such condition as to retain moisture
6. Destroy insects, as well as their eggs, larvae, and breeding places
7. Leave the surface so as to prevent erosion by winds and water

Included in the primary tillage machine group are moldboard, disk, and chisel plows.

In order to understand the operation of primary tillage machines, it is necessary that the mechanic be able to identify the machine parts and understand their functions.

Moldboard plow

Part	Function
Beam	The frame that holds the plow bottoms in the correct position
Frog	That part of the plow to which all other bottom parts are bolted
Share	That part of the plow bottom that cuts the underside of the furrow slice away from the land
Moldboard	Turns the furrow slice on edge
Landside	The long flat metal piece which absorbs the side forces created when the furrow is turned and levels the plow bottom into a free floating position

Bottom	Lifts, turns, and pulverizes the soil
Coulters	The round disk blade used for cutting the earth and trash ahead of the plow

Several types of moldboards are built by manufacturers of agricultural machinery. Each type has been designed to perform a specific function. These are:

1. Stubble
2. General purpose
3. Breaker
4. High-speed

Three materials are used in the manufacture of moldboards.

1. Soft-center steel
2. Crucible steel
3. Chilled cast iron

Soft center steel moldboards are used under most conditions because of their ability to scour. Steel plows are used most in the Middle West because of their wear-resistant qualities. Chilled plows are better for sandy, gritty, and gravel soils. The share of moldboard plows, which provides the cutting edge, is made of plain crucible steel, soft-center steel, chilled cast iron, and cast iron.

Several types of moldboard plows are produced by agricultural machinery manufacturers for use by farmers. These are:

1. Trailing
    a. Regular -- one to eight bottoms
    b. Two-way -- one to four bottoms
    c. Middlebreakers -- one to four bottoms

2. Mounted
    - a. Regular -- one to five bottoms
    - b. Two-way -- one to two bottoms
    - c. Middlebreaker -- one to four bottoms
3. Semi-mounted
    - a. Steerable -- over five bottoms
    - b. Non-steerable -- one to five bottoms

The depth that a plow penetrates the soil and the width of the furrow are determined by the suction created by the share. Common degrees of suction used on most plows are

1. Regular-suck (3/16")
2. Deep-suck (5/16")
3. Double-deep-suck (3/8")

Shares with a regular-suck are best suited for light, easy-to-penetrate soils. Shares with a deep-suck are built for soil that is dry and hard, and the double-deep-suck is used in stiff clay soils, gravel land, and other soils where penetration is difficult.

The depth that a plow penetrates the soil is determined by the landside. The plow bottoms level off when the heel of the landside contacts the furrow sole.

The factors of major concern to the mechanic in adjusting a plow to operate properly are these:

1. Proper draft
2. Proper hitching

Draft is the amount of resistance that a plow creates to the source of power. Draft should be kept as light as possible in order to conserve tractor power. Draft on a plow is caused by several factors.

1. Soil condition
2. Topography

3. Adjustment of the plow
4. The hitch to the tractor
5. Depth and rate of plowing
6. Sharpness of the shares, coulters, and jointers

The following table illustrates the amount of draft exerted on a plow bottom in the various soil types

Soil	Resistance (pounds per square inch)
Sandy	3
Sandy loam, moist	3-4
Sandy loam, dry	4-6
Silt loam, moist	5-6
Silt loam, dry	6-7
Clay loam, moist	6-7
Clay loam, dry	7-8
Heavy clay, dry	9-10
Heavy clay sod	10-1

The two types of draft that work on a plow should be thoroughly understood and adjusted if the plow is to function properly.

1. Vertical
2. Horizontal

On trailing plows the vertical line of draft is a straight line from the draft center of the plow to the tractor drawbar looking at the plow from the side. The draft center of the plow is a point near the top of the share and about 2 inches from the landside. It is located below the beam if one bottom is used, halfway between the beams if two bottoms are used. (Refer to Machines for Power Farming, p. 166, for example.)

Tendencies of the plow to ride out of the ground or the rear of the plow to bob out of the ground are symptoms of improper vertical draft adjustment. These problems can be corrected by raising or lowering the plow drawbar to align with the vertical line of draft.

The horizontal draft line is a straight line from the draft center of the plow to the tractor drawbar looking down on the plow. The draft center for the plow is halfway between the draft center of the two outermost shares and halfway between the rear wheels of the tractor. Ideally the plow draft center and the tractor pull center should be in line if the plow is to function at its best.

The easiest way to make a horizontal adjustment is to make the tread of the tractor wheels fit the trailing plow. In the event that the two centers cannot be lined up, an adjustment halfway between these two points should be made. Unevenness of furrow slices and hard-steering of the tractor are indications of improper horizontal draft adjustment. (Example--Machines for Power Farming, p. 167.)

Often it is necessary to adjust the clearance under the landside and between the landside and furrow wall. These adjustments are given in Farm Machinery and Equipment, p. 101.

The draft on mounted plows is adjusted hydraulically from the tractor. Any adjustments that are needed should be made according to the manufacturers specifications as set down in the service manuals.

Mounted plows are also classified according to the type of hitch used to attach them to the tractor. These include:

1. Single-point hitch, free floating; rear-mounted
2. Three-point, free floating, variable-pitch, rear mounted
3. Hydraulically supported three-point suspended
4. Hydraulically suspended free-floating three-point variable pitch

On the single-point hitch free floating, rear-mounted plow, the plow beam extends to a point ahead of the tractor rear axle. The height of the hitch point is adjusted manually or hydraulically. The weight of the plow causes the plow bottom to enter the ground as it is lowered into the ground. As the plow moves forward, the suction created by the share and the weight of the soil being moved causes the plow to penetrate the soil until the heel of the landside comes into contact with the furrow. The depth of penetration is determined and regulated by the height of the hitch point.

The three-point, free floating, variable pitch, rear-mounted plow uses three links for connection to the tractor. The upper link adjusts the plow for deep or shallow plowing. The other two links are non-adjustable. The plow enters and penetrates the soil in the same manner as the single-point-hitch-type plow.

The hydraulically supported three-point suspended plow is supported during plowing and moved by hydraulically controlled linkage. This linkage holds the plow up, but does not force it into the soil. When soil resistance increases, the upper attaching link pushes against a spring controlling a hydraulic mechanism that raises the plow. The increase in weight on the rear tractor tires caused by the plow rising increases the traction on the tractor wheels.

The landside does not function as far as downward forces go, but it does absorb the side thrusts of the plow.

The hydraulically suspended, free floating three-point variable-pitch plow combines the features of the other three plows. The plow bottoms enter the soil and come to the correct depth after the landside makes contact with the furrow sole. From this point, the plow is free floating. The depth of penetration of the bottoms is controlled by adjusting a crack which points the bottoms up or down.

The following attachments are available for the moldboard plow.

1. Trash cover boards
2. Jointers
3. Weed rods

Disk plows

The disk plow has one or more rolling cutters. It creates no suction, as a moldboard plow does, and depends on weight and disk angle for penetration. Its maintenance cost is low, and its parts last a long time.

The disk plows work well under the following adverse conditions:

1. Wet, sticky, non-scouring gumbo, hardpan or black waxy soil
2. Soils containing large stones or rocks
3. Dry, hard soil
4. Rooty, stumpy soil
5. Abrasive soils

The three main types of disk plows are

1. Direct-mounted
2. Semi-mounted
3. Trailing

Direct-mounted plows are attached to the tractor by one-, two-, or three-point hitch linkages and can be raised or lowered hydraulically. They usually are rear-mounted and have a rear wheel to absorb the side thrust.

Semi-mounted disk plows are attached to the tractor drawbar or by a special drawbar. They are raised by moving a lever at the front of the plow. A long rod which extends to the tractor drawbar is used to steer the rear wheel.

Trailing disk plows have three wheels for support and can be pulled by any make of tractor. The front wheel performs the following functions:

1. Helps lift the plow
2. Turns sideways for steering the plow
3. Absorbs some of the side thrusts

The rear wheel is non-steering, but it absorbs thrusts and lifts the rear part of the plow.

The draft created by a disk plow is usually about the same as that of the moldboard plow; but since the disk plow is often heavier than the moldboard plow, its draft is usually greater.

The disk plow is comprised of the following parts:

1. Disk blades
2. Standards and clamps
3. Bearings
4. Beams and frames
5. Lifting and steering mechanisms
6. Wheels

Three types of adjustments are common to all types of disk plows.

1. Cutting angle adjustment
2. Width-of-cut adjustment
3. Vertical adjustment of the disk blade

Disk blades will not cut if they roll straight ahead, but must work at an angle. This angle is measured between a perpendicular line from the line of travel, to the axle line of each disk blade. The cutting angle of the disk plow can be changed by either of two methods.

1. Pivoting the beam
2. Pivoting the blade and standard
   (See Machines for Power Farming, p. 199-200.)

Two adjustments can be made to adjust the width-of-cut made by the plow.

1. Front disk blade cut adjustment
2. Cutting width adjustment
   (See Machines for Power Farming, p. 201-202.)

The vertical adjustment or position of the disk blade, also called the tilt or slant, directly affects the degree of penetration of the plow, in relation to the amount the disk is inclined from the vertical position. Two methods can be used in tilting the disk.

1. Standard-to-beam method

2. Standard-to-bearing method
   (See Machines for Power Farming, pp. 201-202.)

3. Chisel plow
   (Refer to references for this material.)

Suggested Teaching-Learning Activities

1. Demonstrate how primary tillage machines used by farmers in the area work in the soil. After showing the proper operation of each machine, throw it out of adjustment and have students observe the results. Have students study each machine part to learn its functions.

2. Bring examples of all hitches discussed in the content before the class. Have students study their construction and operation.

3. Bring to class primary tillage machines in need of adjustment and repair of each type discussed in the content. Follow the procedure below when making the needed adjustments and repairs.

   a. Operate the machine in the field and note any malfunctions in operation.

   b. Inspect the machine, noting worn and broken parts or parts out of line or adjustment.

   c. Following the operator's and service manuals, make the necessary repairs and adjustments.

   d. Lubricate the machine for field operation.

   e. Test the machine in the field and make adjustments necessary for proper operation.

Suggested Instructional Materials and References

Instructional materials

Demonstration machines of each type identified in the content

References

1. Farm Machinery and Equipment, pp. 93-144.
2. Machines for Power Farming, pp. 151-224.
3. Operator's manuals
d. Service manuals

Suggested Occupational Experience

Following the procedures outlined in the teaching-learning activities, have students adjust, repair, and lubricate primary tillage machines at the local agricultural machinery dealership.

V. To (1) identify the parts and types of secondary soil tillage machines and understand their functions and to (2) adjust, repair, and lubricate these machines

Teacher Preparation

Subject Matter Content

Machines that stir the soil at comparatively shallow depths are classified as secondary tillage machines. Included in this group are the various types of harrows, rollers, and pulverizers, and tools for mulching and fallowing. These machines are designed to perform the following:

1. Improve the seedbed by greater pulverization of the soil
2. Conserve moisture through summer-fallow operations by killing weeds and reducing evaporation
3. Cut up crop residue and cover crops and mix vegetable matter with the top soil

4. Break up clods, firm the topsoil, and put it in better tilth for seeding and germination of seeds

5. Destroy weeds on fallow lands

6. Fill in air spaces and level the ground

Several types of harrows are made by agricultural machinery manufacturers for farm use.

1. Disk harrows

2. Spring-tooth harrows

3. Spike-tooth harrows

The disk harrow mixes the soil, breaks up clods, levels the lands, aerates the soil, and kills weeds. It works somewhat like a moldboard plow, for it raises the earth and pushes it to one side.

In operation, the disk harrow is balanced. The side forces are balanced: one-half of the disk blades are placed with their concave cutting faces in one direction and the other half in the opposite direction.

The depth of penetration of the disk blades is controlled in the following ways:

1. Using a heavy or light harrow

2. Adding weights to the harrow

3. Using few or many disks per harrow

4. Exerting hydraulic forces, up or down

5. Using transport and depth regulating wheels

6. Using dull or slump disk blades

7. Using smaller or larger disks

8. Using cutout or notched disks

9. Adjusting the angle of the disk gangs

Disk type harrows are grouped into two main types.

1. Regular
2. Offset

The regular type disk harrow is grouped according to the type of action created by the disk.

1. Single-action
2. Double-action

A single-action disk usually consists of two assemblies of disks, called gangs, which are joined together by a common shaft or bolt through their centers and all rotate together. The two gangs are set at angles to each other and the line of pull, and the soil and other field materials are always moved outward from the harrow center.

In recent years a new development in disk harrow design has separated disk harrows into other classifications.

1. Rigid
2. Flexible

A group of two or more disks that rotate in the same direction is referred to as a gang. The disks are held together by a shaft, either round or square, called the arbor bolt, and held apart by spacers. The disks, shaft, and spacers turn together.

The two-section type with one section trailing behind the other is the double-action or tandem-type disk harrow. It is called a double-action plow because

1. It has two sections
2. The rear section turns back the furrows created by the front section. The gangs of the first section turn the soil to the left, and the rear section turns the soil to the right.

Disk harrows vary in size. Several systems are used by manufacturers of the machines to classify them by size.

1. Width of cut
2. Diameter of the disk blades
3. Number of disks

The disks used to turn the soil on a disk harrow are similar to those of the disk plow. Several types of harrow disks are available for use on the disk harrow. Common types are

1. Plain
2. Crimped disk
3. Auburn
4. Scalloped

A disk plow usually has two or three bearings per gang. These may be of either the friction or anti-friction type. The latter are used more because they decrease replacement costs by lessening wear on machine parts.

The spring-tooth harrow is one of the most useful machines available to farmers. It is a drag-type harrow capable of doing the following:

1. Level and smooth the soil
2. Work well in rough, stony soils
3. Remove plant growth from the soil without cutting it up
4. Break the soil crust and penetrate as deep as seven inches
5. Pull weed roots to the surface where the sun dries and destroys them
6. Mix trash and stubble
7. Tend to aerate and warm the soil by stirring it

There are two main types of spring-tooth harrows.

1. Lift
2. Trailing

The lift type is built to be raised by the hitch that is a part of the tractor.

The harrow teeth are made from spring steel which has been forged and rolled to shape and then oil tempered. Their variables in thickness are determined by the toughness of the work that is to be done, but the average thickness is 5/16 inch.

Two main types of teeth are used on spring-tooth harrows.

1. Those with the end of the tooth sharpened
2. Those having reversible parts

The spring tooth harrow is made up of the following parts:

Part	Function
Harrow teeth	To prepare land for seed
Tooth bar	To support the harrow teeth
Tooth bar standards	To provide clearance for the tooth bar over soil and trash
Tooth clamps	To attach the teeth to the tooth bar
Frames	To support the harrow teeth, standards, and other parts
Shoes	To come in contact with the ground
Tooth penetration levers	To set the depth at which the machine is to operate

Another drag-type harrow is the spike-tooth harrow. It is often called the peg-tooth harrow. It is designed to do the following:

1. Smooth and compact the topsoil
2. Fill large air spaces left from plowing
3. Break up lumps and clods
4. Finish the ground just before planting
5. Cover small seeds broadcast over the surface
6. Break crust and destroy small weeds
7. Cultivate small plants

The two main types of spike-tooth harrows are

1. Rigid
2. Flexible

The rigid harrow has one-piece end rails holding the teeth bars, which make all the teeth cut the same depth. The flexible harrow has jointed end rails, which allow the individual tooth bars to rise vertically to go over obstructions.

The spike-tooth harrow is made up of the following parts:

1. Spike teeth
2. Tooth bars
3. Tooth clamps
4. Frame

Several spike-tooth harrow rigid-frame and tooth bar arrangements are in use. They include

1. Closed square-end harrow
2. Open-end harrow
3. Curved-end-type harrows
   (See Machines for Power Farming for discussion of each type)

The rotary shredder is a popular American tillage machine because of its wide range of functions. It cuts, shatters, tears, chops, mows, pulverizes, spreads, and mulches.

Rotary shredders use high speed revolving flails, blades, or hammers to carry out these functions. On some shredders the flails, blades, or hammers travel about 9000 feet per minute.

Two types of machines are made by agricultural machinery manufacturers.

1. Trailing
2. Mounted

About half of the machines have a long horizontal shaft with attached flails or hammers. This arrangement gives a hammer mill effect and permits the shredding of stalks and trash into small pieces. The other machines have a short vertical or horizontal shaft called a spindle. One end of the spindle is driven directly from the tractor PTO, and the other end has a plate or hub which carries the cutting knives. The spindle knife cutter has a propeller-like appearance, as seen from the soil side. (See Machines for Power Farming, p. 264.)

Several types of cutting assemblies are used on rotary shredders.

1. Rotor or cylinder cutters
2. Vertical or horizontal spindle cutters
3. Knives for rotary cutters

Rotor or cylinder cutters have a long axle that operates parallel to the ground. The flails which are attached combines with it to constitute the rotor. The rotor may operate with or against the direction of travel, but the operation against the direction of travel is most desirable because the machine does a better job of cutting weeds and pulverizing trash.

Flails consist of a hammer and a length of chain. The hammers weigh the same, but the chains are of different lengths, causing the machine to do a better job of flailing. The hammers usually take on the shape of a "T" or a "Y". On some machines, flails are used in combination with a shear bar. The flails cut the vegetation against a shear bar and pulverize the materials after they are cut.

On vertical and horizontal spindle cutting machines the horizontal spindle travels above and parallel to the rows. As many as five spindles may be used, thus providing a closer cut. Shredders operating with a type of rotor assembly are most useful on rough, hilly ground.

The rotary shredder is driven from the PTO shaft of the tractor. The direction of the drive is changed by a set of bevel gears carried in the housing of the shredder. The vertical-spindle cutters are driven directly from the bevel gears. The vertical spindle passes through a bearing attached to the top of the plate of the shredder and the cutter hub is attached to the lower end of the spindle. A shear pin is used as a safety feature in case the cutters hit something solid.

Soil pulverizers are machines used to put finishing touches to the seedbed. They pulverize lumps and clods, pack the soil particles after plowing or harrowing, aid in holding moisture, and eliminate air pockets.

Soil pulverizers consist of an axle between two bearings spaced evenly with wheels or sprockets. The wheels are made of cast iron and are constructed with a rim on the hub to keep dirt out of the wheel cylinder.

Soil pulverizers, similar to disk harrows, are of two types.

1. Single section
2. Double section

Because its axles are supported by a hinged bearing housing, the double section pulverizer, or tandem type, provides a finer seedbed and more flexibility.

Several types of wheels are used as soil pulverizers. Some of these types may be used at the same time, depending on the function desired.

1. Plain ridge
2. Serrated ridge
3. Wavy ridge
4. Sprocket

When plain ridge wheels are the only wheels used on the machine, it packs the soil. With the addition of sprocket wheels, the machine pulverizes and packs at the same time.

The soil pulverizer is comprised of the following parts:

1. Wheels
2. Sprockets
3. Frame
4. Bearings

Suggested Teaching-Learning Activities

1. Have students disassemble each type of tillage machine discussed in the content and learn its parts. Point out to the students the materials used in constructing each part and the function of each part in the total operation of the machine.
2. Demonstrate proper and improper operation of each of the tillage machines identified in the content under field conditions.
3. Bring to the class secondary tillage machines of each type studied to be adjusted and repaired. Follow the procedure below when correcting the faults.
    a. Operate the machine in the field to discover any malfunctions in operation.
    b. Inspect the machine, noting worn and broken parts and parts that are out of line or adjustment.
    c. Following the operator's and service manuals, make the necessary repairs and adjustments.
    d. Lubricate the machine for field operation.
    e. Test the machine in the field and make all adjustments necessary for proper operation.

Suggested Instructional Materials and References

Instructional materials

1. Machines for disassembly

b. Machines for use in demonstrating proper and improper field operation

References

1. Farm Machinery and Equipment, pp. 145-166

2. Machines for Power Farming, pp. 227-277

3. Operator's manuals

4. Service manuals

Suggested Occupational Experience

Have students adjust, repair, and lubricate secondary tillage machines at the local agricultural machinery dealership following the procedure outlined in the teaching-learning activities.

VI. To (1) identify the parts and types of cultivating machines and understand their functions and to (2) adjust and repair these machines

Teacher Preparation

Subject Matter Content

Cultivation requires a tool to stir the surface of the soil to a shallow depth in such a manner as to destroy young weeds and promote crop growth. Weed control cultivation may start on the prepared seedbed prior to planting or after planting, before the emergence of the plants. Usually cultivation begins soon after emergence of the young crop seedlings, as weeds generally emerge about the same time as the crop.

Cultivating machines are designed to perform the following functions on the soil:

1. Retain moisture by
    a. Killing weeds
    b. Loosening mulch on surface
    c. Retaining rainfall
2. Develop plant food
3. Aerate the soil to allow oxygen to penetrate soil
4. Promote activity of microorganisms in the soil

Several types of cultivators are used by farmers, the type and size depending upon the acreage, kind of crop, soil type and condition, rainfall, type of farming practiced, and kind of power available.

1. Mounted
    a. Central-forward mounted
    b. Central-forward and rear-mounted
    c. Rear-mounted
2. Trailing
3. Lift up or mounted tiller
4. Dragbar
5. Rigid-frame

The dragbar type allows the cultivator teeth to rise over uneven surfaces; whereas on the rigid-frame type the teeth or standards are fastened directly to the frame and are inflexible on uneven surfaces.

The "business end" of the cultivator, those parts that engage and work the soil, are referred to as steels, points, or teeth. More specifically, they are referred to in the following manner:

1. Sweeps
2. Shovels
3. Spikes
4. Disks
5. Knives and hoes

Within each type, manufacturers have designed and built items to perform specific functions.

Sweeps	Use
Blackland sweeps	For use on sticky, blackland soil
Mixed-land sweeps	For high-speed cultivation on most other soils
Planter sweeps	Have prominent wings for clearing beds for planting
Plowing sweeps	For use in blank listing, bursting, and bedding
Duckfoot sweep	For use on deep-rooted weeds, fallowing, and stubble mulching
Shovels	
Spear point	For use in working beds and flat land
Irrigation shovel	For cultivating irrigated land
Chisel-tooth shovel	Use for close, deep cultivation and breaking of hard-pan
Turn shovel	For farrowing

Knives and hoes	Use
Round-turn knife	For cultivating such crops as sugar beets
Square-turn knife	For flat cultivation on beds on flat land
Crescent hoes	For tilling the side of beds of beats and vegetables
Flat hoes	For use when flat work is desirable on such crops as cotton and corn
Mulch hoes	For cutting through fibrous soil without choking off
Furrowers	For digging furrows and trenches

The standards on the cultivator connect the points with the frame of the cultivator. Several types are used on cultivators, each of which is built to perform differently and to conform to the type of farming prevalent in the area.

1. Stiff
2. Spring-trip
3. Friction-break
4. Flexing
5. Regular or high clearance
   (See Machines for Power Farming, pp. 381-382, for a discussion of each type.)

Like cultivator standards, several types of cultivator frames have been built by agricultural machinery manufacturers, the main ones of which are

1. Front-mounted cultivator gangs
2. Rear-mounted tool bar
3. Mounted-frame cultivator or field tiller
4. Wheel-mounted frame or carrier

5. Carrier-type field cultivators
6. Dragbar
   (See Machines for Power Farming, pp. 383-385.)

A variety of attachments have been developed for use on cultivators.

1. Rotary hoes
2. Disk hillers
3. Fertilizer application attachments
4. Seeders
5. Weeder-mulchers
6. Row-crop thinners

In recent years the rotary hoe has been popular as a cultivating tool, because it performs some rather specific functions of soil tillage.

1. It breaks up crusted soils to allow the crop seedling to come through the ground.
2. It up-roots small weeds and exposes weed seedlings to the drying effect of the sun.
3. It aerates and mulches the top soil, thus improving plant growth.
4. If pulled in reverse, it gives a treading action that smashes and pulverizes clods and trash.

As is the case of most other machines, rotary hoes are of either the mounted or trailing type. The hoes are made up of gangs, usually two per section, consisting of an axle and digger wheels.

Diggers are of several types, depending on the type of soil on which they are to be used and the degree of soil penetration desired. They are made of small, angle irons curved and sharpened at one end.

Suggested Teaching-Learning Activities

1. Have students disassemble each type of cultivating machine discussed in the content and learn its parts and their functions. Point out to the students the materials used in constructing each part and the function each part plays in the total operation of the machine.

2. Demonstrate proper and improper operation of each type of cultivating machine under field conditions.

3. Bring to the class cultivating machines that are in need of adjustment and repair. Follow the procedure below when making the needed adjustments and repairs.

    a. Operate the machine in the field to discover any malfunctions in operation.

    b. Inspect the machine, noting worn and broken parts and parts that are out of line or adjustment.

    c. Following the operator's and service manuals, make the necessary repairs and adjustments.

    d. Lubricate the machine for field operation.

    e. Test the machine in the field and make any adjustments necessary for proper operation.

Suggested Instructional Materials and References

Instructional materials

1. Machines for disassembly

b. Machines for use in demonstrating proper and improper field operation

References

1. Farm Machinery and Equipment, pp. 209-234.

2. Machines for Power Farming, pp. 373-397.

3. Operator's manuals

4. Service manuals

Suggested Occupational Experience

Have students adjust, repair, and lubricate cultivating machines at the local agricultural machinery dealership, following the procedure outlined in the teaching-learning activities.

VII. To (1) identify the parts and types of crop planting machines and understand their functions and to (2) adjust and repair these machines

Teacher Preparation

Subject Matter Content

The purpose of the crop planter is to sow seeds in rows or beds, on flat land and in trench bottoms efficiently and in correct amounts at the proper depth.

There are two types of crop planting machines.

1. Row-crop
2. Drill

Row-crop planters are further divided into two large groups.

1. Those that drill seed only
2. Those that drill and plant in check rows

Planters, like other machines, are of the mounted or trailing type. The mounted type may be further divided according to the means of attachment to the tractor.

1. Front-mounted
2. Rear-mounted
3. Semi-mounted
4. Unit runner

With the exception of the unit runner type, almost all planters use a clutch to drive the seed plates, which in turn are driven by the drill shaft. The clutch action permits intermittent movement of the drill shaft so that seeds for hills can be accumulated in the shank valves.

Row-crop planters are made up of the following units.

1. Hopper and seeding mechanisms
2. Hopper-to-opener assemblies
3. Drive and checking devices
4. Fertilizer and other attachments

Four basic hoppers are used on row-crop planters.

1. Single seed
2. Reverse-feed cotton
3. Richmond
4. Duplex

The hopper most commonly used to plant row crops is the Richmond type. It consists of the following parts:

1. Bottom
2. Filler plate
3. False ring
4. Knockout pawl
5. Hopper ring gear
6. Pinion gear
7. Seed plate

Several terms are used to describe the part that leads from the hopper to the furrow openers. Among these are boat, post, shank, and flexible ribbon tube. The furrow openers are held in place by a standard.

Two types of shanks are used on row-crop planters.

1. Those held rigidly in place by the front frame members
2. Those that are free to float with the contour of the field

Some are plain. When this type of planter is used, the seed is dropped directly from the hopper to the soil. Others are valved to form a "V" for the seed to fill in and then release to the soil.

The purpose of the furrow opener is to open the soil at a desired depth for the seed to be sown. Several types of furrow openers are used on row-crop machines, such as'

1. Variable-depth
2. Constant-depth
3. Curved runner
4. Fully curved runner
5. Stub runner
6. Shovel
7. Single-disk
8. Curved double-disk
9. Coulter double-disk

To be in an atmosphere condusive to good germination, the seed must be properly covered. The row-crop planter has a variety of furrow coverers to provide this environment.

1. Open-center press wheel
2. Rubber-tired press wheels
3. Zero-pressure rubber tires
4. Disk coverers
5. Blade coverers
6. Shovels
7. Knife blade

Fertilizer sowing attachments have been developed for use on row-crop planters. These attachments have two types of feeding mechanisms.

1. Star or spur wheel type
2. Plow type
   (See Machines for Power Farming, pp. 340-341.)

The primary purpose of the grain drill is to sow grain in correct amounts and at proper depths. It also pulverizes and firms the soil.

Several types of grain drills have been developed to meet the varying needs of the farmer.

1. Plain
2. Fertilizer
3. Surface
4. Deep-furrow

The plain drill is used primarily for planting grain crops. It is not well adapted to planting grass seed or applying fertilizer. The fertilizer drill sows all the seed that the plain drill plants and also drills or broadcasts fertilizers. The other two types sow the seed at different depths in the soil. The plain or fertilizer type drills can be of either the surface or deep-furrow type.

Several devices are used on grain drills to feed the seed into the seed tube. These devices are

1. Double-run seed feeding device
2. Fluted-roll feeding device
   (See Machines for Power Farming, pp. 350, 352.)

When the double-run feeding device is used, the rate of flow can be controlled in the following way.

1. Select the size of the feed wheel recommended on the drill charts for a certain seeding rate.
2. Change the speed of the wheel by changing gears and sprockets or both.

3. Change the position of the feed gate in the cup.
4. Use reducers below the feed wheel.

The rate of seed flow on the fluted-roll devices is regulated by

1. Moving the fluted rolls endways
2. Adjusting the gates or latches to one of three positions
3. Changing the speed of the feed shaft

Rolling furrow openers are most commonly used as grain drills. Essentially they are disks or coulters that cut trash and lumps and open the soil for seed placement. Several varieties of furrow openers are used on grain drills.

1. Single disk with open-delivery boot
2. Single disk with closed-delivery boot
3. Double-disk coulter
4. Double-disk curved-blade

Furrow openers are guided and pulled by dragbars or drawbars. Their purpose is primarily to

1. Pull and space openers
2. Absorb side thrusts occurring when the openers strike obstructions

After the seed has been sown, seed coverers cover it. These coverers are of several types.

1. Drag chain
2. Drag weights
3. Weighted steel fingers
4. Press wheel attachments

The coverer is attached immediately behind the furrow opener.

A variety of attachments have been developed for use on the grain drill. These are identified and discussed in the operator's manuals for the specific machines. Two of the most important attachments, however, the fertilizer and grass seeding attachments, are discussed in Machines for Power Farming, pp. 363-366.

Sowing seed in proper amounts is a primary function of both the row-crop and drill-type planters. These machines should be checked and calibrated if they are sowing seed improperly. The following techniques should be used when calibrating planting machines:

Row-crop planter

The calibration procedures below use corn as the example crop. The operator's manual gives the specifications to be used when calibrating for other crops.

Step 1: Check planter parts.

Carefully check the power train from the ground drive wheels to the seed plate. Loose or worn sprockets, gears, and chains can affect metering accuracy, particularly on the seed-plate drive and the power train from the drill shaft to the hopper. Replace worn cut-off pawls, knockout pawls, and hopper bottom rings. When replacing worn pawls, check for weak springs.

Step 2: Select proper population for fertility level.

For any field with the proper fertility level, there is a population of stalks at harvest that give the maximum yield of corn. The following table shows the number of kernels to plant for the desired number of stalks per acre at harvest.

Expected yeild per acre	Kernels planted per acre	Stalks at harvest per acre
75 bushels	13,300 kernels	12,000 stalks
100 bushels	16,500 kernels	14,000 stalks
125 bushels	20,000 kernels	17,000 stalks
150 bushels	25,000 kernels	20,000 stalks

Step 3: Read the owner's manual carefully.

The owner's manual tells how to adjust the corn planter to obtain the correct population. It is also an excellent guide for determining the speed of the planter for a given planting rate.

Do not exceed the maximum planting speed recommended in the manual. When this speed is exceeded, the seed plate turns too fast for accurate planting and uniform kernel spacing.

By using seed plates with more cells than the standard 16-cell plate, a faster speed can be used and obtain the same planting rate. The manual will indicate whether plates with more than 16 cells can be obtained for the planter.

Step 4: Match seed to seed plate.

It is desirable to have an average of 100-percent or slightly higher cell fill. A 100-percent cell fill means that, on the average, one kernel is dropped from each cell. If, for example, 16 kernels are dropped in one turn of a 16-cell seed plate, the cell fill is 100 percent. If 12 kernels are dropped, the cell fill is 75 percent. If 20 kernels are dropped, the cell fill is 125 percent. For best results and to avoid damage to the seed as it passes through the hopper mechanism, the cell fill should be 100 percent or slightly higher, up to a maximum of 105 percent.

To be certain that the cell fill is accurate, seed plates should be matched to the seed. These can be matched either on a seed-corn test stand or by a calibration run on the open ground in a lane or barnlot where all the kernels can be counted. Whichever method is used, check the rate at field speed and desired planting rate.

In selecting the correct seed plate, begin with the seed plate recommended on the bag of seed corn. Small variations between seed plates of the same size and seed corn of the same grade can result in serious planting errors. Remove any rust, seed treatment, or rust preventative from cells before making the test.

Step 5: Adjust planter for desired planting rate.

Using the owner's manual and the table below, set the planter to plant the number of kernels desired.

Spacing of Kernels for Planting Rates of	Row Spacing			
	36 inches	38 inches	40 inches	42 inches
12,000 per Acre	14.5	13.7	13.1	12.4
14,000 per Acre	12.4	11.8	11.2	11.7
16,000 per Acre	10.9	10.3	9.8	9.3
18,000 per Acre	9.7	9.2	8.7	8.3
20,000 per Acre	8.7	8.2	7.8	7.5
24,000 per Acre	7.3	6.9	6.5	6.2
28,000 per Acre	6.2	5.9	5.6	5.3

Step 6: Calibrate in a barnlot or roadway before planting.

Planting speed can cause a wide variation in planting rates. For this reason, final calibration must be made at planting speed on a roadway or barnlot where all of the kernels can be counted over a short distance. Leave the planter in a raised position and use a wire or string to engage the seedplate drive. The following table shows how far to drive for various row spacings. Each row is 1/200 of an acre. To obtain the planting rate per acre, count the kernels from each row and multiply by 200.

Row spacing	36 inches	38 inches	40 inches	42 inches
Distance to Drive	72 feet	69 feet	66 feet	63 feet
Kernels to count for planting rates of				
12,000 per Acre	60	60	60	60
14,000 per Acre	70	70	70	70
16,000 per Acre	80	80	80	80
18,000 per Acre	90	90	90	90
20,000 per Acre	100	100	100	100
22,000 per Acre	110	110	110	110

Determine the planting rate for each of the planter rows and list these rates separately, in order to determine whether one of the hoppers is giving a poor drop of the seed. If all of the planter parts seem to be functioning properly and the seeding rate is higher than the rate for which the planter is adjusted, then a smaller seed plate should be used. If the planting rate is not high enough to match the adjusted rate on the planter, a larger seed plate should be used.

To get an accurate measure of the planting rate, make all of the calibration runs at planting speed. The planting rate in these calibration runs will probably be slightly higher than the field rate, even when the seed is perfectly matched to the seed plate. This is due primarily to the reduced slippage of the drive wheels on the smooth surface.

In making the calibration run, allow a few hundred extra kernels to compensate for the difference between the calibration rate and field rate. Suppose that it is desirable to calibrate a planter at 5 miles per hour to drop 18,000 kernels, and it was found that after making a few calibration runs the planter was dropping 18,500 kernels. In the field, this planting rate will be reduced to 18,000 or slightly less, and should be satisfactory.

Step 7: Make a field check.

When the planter has been calibrated to plant a given number of kernels per acre on a roadway or barnlot, the serviceman can be fairly confident that the planter will give approximately the desired planting rate. As a final check, however, dig out several kernels along the row and make an estimate of the average kernel spacing. By checking this spacing with the desired rate, he can determine the accuracy of calibration and make whatever adjustments are necessary on the planter.

How to determine field speed

In planting corn, you must know how fast the planter is moving, especially if granular or liquid chemicals are being applied at the same time. Field speed can be determined in the following way:

1. Carefully mark off a distance of 176 feet in the field.
2. Check the number of seconds required to drive between the markers with a stop watch or watch with a sweep second hand.
3. Divide the time in seconds into 120 for speed in miles per hour.

The chart below lists the time in seconds for speeds up to 7 miles per hour.

Time to Drive 176 Feet	Speed
120 seconds	1 mile per hour
60 seconds	2 miles per hour
40 seconds	3 miles per hour
30 seconds	4 miles per hour
24 seconds	5 miles per hour
20 seconds	6 miles per hour
17 seconds	7 miles per hour

Source of the above listed steps is University of Illinois, College of Agriculture, Circular 840.

Grain drill

1. Adjust the rate of seeding control for the desired amount of seed per acre.

2. Place canvas under furrow openers after the drill is in gear.

3. Jack up the wheels and lower the furrow openers after placing the drill in gear.

4. Place a sufficient quantity of seed in the drill to plant desired acreage (1/10 to 1/4 acre recommended).

5. Compute the number of times the wheels must be turned to plant 1/4 acre.

   Example:

   a. $\frac{\text{43560 sq. ft. per acre}}{\text{Width of drill}}$ Equals feet traveled per acre

   b. $\frac{\text{Feet traveled per acre}}{\text{Circumference of wheel}}$ Equals revolution of wheel for one acre

   c. $\frac{\text{Revolutions traveled per acre}}{4}$ Equals revolution of wheel for 1/4 acre

6. Turn drill wheel desired number of times to plant 1/4 acre.

7. Weigh seed deposited and multiply by 4 to convert to one acre basis. If the required amount of seed was not deposited, adjust according to the type of drill.

In adjusting the fluted type grain drill, first set the feed shaft and gates according to the size of seed being sown. Rate of seeding is set by adjusting the feed shaft shifter, of which there are two in drills having more than 8 disks--one for each half of the drill. Both must be kept in the same position on the feed index plate, which is provided with a row of notches.

The internal double run type feed consists mainly of a feed wheel and a feed gate. The wheel is smaller on one side for planting oats, barley, treated wheat, and other grains. The adjustable gates regulate the size of feed openings. In either situation, adjust to make up the difference in the previous setting and the calibrated amount. Then start the procedure from the beginning.

Suggested Teaching-Learning Activities

1. Have students disassemble each type of crop planting machine discussed in the content and learn its parts and functions. Point out to the students the materials used in constructing each part and the function each part plays in the total operation of the machine.

2. Demonstrate proper and improper operation of each type of crop planting machine under field conditions.

3. Bring a row crop plate hopper before the class and demonstrate what happens when the wrong plates are used to plant a certain crop.

4. Bring to the class crop planting machines that are in need of adjustment and repair. Follow the procedure below when making the needed adjustments and repairs.

    a. Operate the machine in the field to discover any malfunctions in operation.

    b. Inspect the machine, noting worn parts and parts that are out of line or adjustment.

    c. Following the operator's and service manuals, make the necessary repairs and adjustments.

    d. Lubricate the machine for field operation.

    e. Test the machine in the field and make any adjustments necessary for proper operation.

4. Have students calibrate both a row crop planter and a grain drill.

Suggested Instructional Materials and References

Instructional materials

1. Row crop planters and grain drills for disassembly

2. Machines for use in demonstrating proper and improper field operation

3. Machines needing calibration

References

1. Farm Machinery and Equipment, pp. 167-208.
2. Machines for Power Farming, pp. 323-369.
3. Operator's manuals
4. Service manuals

Suggested Occupational Experience

Following the procedures outlined in the teaching-learning activities, have students adjust, repair, and lubricate crop planting machines at the local agricultural machinery dealership.

VIII. To (1) identify the parts and types of sprayers and understand how they function and to (2) adjust and repair these machines

Teacher Preparation

Subject Matter Content

In order to understand spraying machines and their adjustments, the serviceman must understand the reasons for using sprays, the purposes for their use, and the type and compositions of sprays.

Most pests that menace farmers and ranchers can be grouped into four major areas.

1. Weeds
2. Insects and insect-like creatures
3. Diseases
    a. Bacteria
    b. Viruses
    c. Fungi
4. Nematodes

One must know something of the characteristics of these pests to control them effectively with chemicals.

The basic characteristics of weeds important to chemical eradication programs are

1. Life span of the plants
2. Method of reproduction
3. Type of leaf structure

Weeds are generally classified by life span.

1. Annuals
    a. Complete life cycle in one year
    b. Reproduce only by seed
    c. Broad-leaved plants
2. Biennials
    a. Complete life cycle in two years
    b. Reproduce only by seed
    c. Broad-leaved plants
3. Perennials
    a. Live three or more years
    b. Reproduce by seed or vegatatively
    c. Blade or broad-leaved plants

Annuals and biennials can be controlled by eliminating seed production; but since perennials can reproduce by seeds, roots, rhizomes and/or stolens, they create more difficult control problems.

Insects that are troublesome to plants can best be catalogued as follows for chemical control. Certain pests that are not true insects, such as lice, mites, spiders, and ants, are included here because the damage they inflict and their control are similar to characteristics of insects.

1. Chewing insects, surface, or boring
    a. Root
    b. Foliage
    c. Flower
    d. Seed or fruit
2. Sucking insects
    a. Foliage
    b. Flower
    c. Seed or fruit

Seed insects may be insects that attack the seed

1. In the soil at planting
2. On the maturing plant
3. In storage

Plant diseases can be classified as bacteria, viruses, and fungi. All of these are serious pests to modern agriculture.

Bacterial diseases of plants attack most types of field and horticultural plants. These are one-celled microscopic organisms of a low form of plant life. They gain entrance to plants through wounds and natural openings and attack all parts of a plant. The types of damage can be classified as follows:

1.	Galls	abnormal growths on a plant part
2.	Wilts	normally congest the vascular system and affect the entire plant
3.	Cankers	tissue destruction, causing leaf or tissue lesions
4.	Rots	fleshy part of plants, (stems, fruit and others) become soft and slimy

5. Abnormal growth
    a. Dwarfing
    b. Deformed parts
    c. Color changes

Virus diseases are also common to plants. They are frequently transmitted by insects and can attack nearly all plant parts. In plants, "yellows" and wilts are common problems. Little is said about this group of diseases since chemicals available to control or treat them are limited. Chemicals can be used to control the insects that cause and spread the disease.

Many plant diseases are caused by fungi, a low form of plant life. Most fungi develop threadlike structures inside and/or on the surface of the plant that interfere with proper plant growth and development. The various fungi may attack several crops or only specific plants; they may attack specific plant tissue or various plant parts. Fungi can be classified as follows:

1. Scabs
2. Rots
3. Rusts
4. Smuts
5. Molds
6. Powder mildews
7. Blights
8. Leaf spots

An increasingly serious pest in crop production in many areas of the United States is the nematode. It is a small roundworm that lives in the soil and frequently enters the plants through the roots. It lives on the plant juices and creates the following types of problems:

1. Galls or knots on roots
2. Stunts or deforms plant growth
3. Causes injury which permits disease to attack plants

Nematodes are not insects, even though they do cause insect-like damage, and are not controlled effectively by insecticides.

The pests discussed on the preceding page are considered undesirable for one or more of the following reasons:

1. They reduce yields of crops or livestock.
2. They compete for food, water, space, and sunlight.
3. They destroy feed, clothing, buildings, and other facilities.
4. They cause or transmit disease.
5. They cause poisonous or toxic conditions.
6. They are an annoyance to man and/or animal.
7. They lower the quality of desired products.

Pesticides can be divided into major categories much like the pests themselves.

1. Herbicides for weeds
2. Insecticides and miticides for insects
3. Bactericides and fungicides for diseases (There are no effective chemicals for the control of viruses.)
4. Rodenticides for rodents
5. Nematocides for nematodes
6. Molluscicides for mollusks

Herbicides are classified into three types, depending on their effects on plants.

1. Contact
    a. Kill part of plant covered by chemical
    b. Little or no movement of chemical in the plant

    c. Effective on annuals and will not kill roots of biennials or perennials

    d. Examples: D N B P and P C P

2. Growth regulators (systemic herbicides)

    a. Absorbed by foliage or roots

    b. Translocated to all plant parts

    c. Chronic; kills slowly

    d. Overdose on leaves may kill cells and prevent translocation

    e. Effective against annuals, biennials, and perennials

    f. Examples: 2, 4-D, M C P A, and Atrazine

3. Soil sterilants

    a. Prevent growth of all green plants

    b. Varying residual toxicity

Herbicides may be selective or non-selective. A selective herbicide is toxic only to specific plant species; whereas a non-selective herbicide is toxic to all plant species. The ideal herbicide is one that is nearly non-selective; that is, it controls all plants except the desired plant species.

Selective herbicides react differently on various plant species. These factors, which may work independently or in combination with others to control weeds selectively, are

1. Amount of chemical applied
2. Time of application
3. Method of application
4. Chemical and physical properties of the herbicides
5. Genetical or physical properties of the plant

Insect control can be achieved by several methods, of which chemical control is one. Chemical control requires

1. Use of the correct chemical
2. Application of it at the correct time
3. Correct application methods

The four common ways in which insecticides work to kill or control insects are

1. Stomach poisons
2. Contact poisons
3. Repellants
4. Attractants

Stomach poisons must enter the digestive tract of the insect before they are effective. For insects with chewing mouth parts, applying the poison to the surface on which the insect feeds is adequate. Before stomach poisons can work on insects having sucking or syphoning mouth parts, systemic poisons are needed. These are chemicals that become part of the plant or animal tissues from which the insect extracts the juices on which it lives.

Contact poisons are chemicals that can enter the insect by means other than the digestive tract. They may enter through surface tissues or the respiratory tract. These chemicals are most frequently used against insects with sucking mouth parts, although they are generally as effective on insects with chewing mouth parts. Fumigates normally act as contact poisons.

Chemical insect repellants actually do not kill most insects, although they may injure certain types. They are used to keep insects from harming or causing annoyance in a particular place.

An insect attractant, or lure, is a material whose vapor, when reaching the insect, draws the insect to it. There are basically three types of attractants: sex, food, and oviposition lures. These lures may be of synthetic or natural origin. Sex lures seem to be the most effective, but much more research is needed before this method of controlling insects becomes of widespread value.

There are many chemical insecticides available, some for general uses and others for specific uses.

1. Arsenicals
    - a. Stomach poison
    - b. Reduction of their importance by newer chemicals
    - c. Examples: lead arsenate, paris green, white arsenic
2. Fluorine compounds
    - a. Stomach poison
    - b. Commonly used to control animal insects
    - c. Examples: sodium fluoride, cayloite
3. Clorinated hydrocarbons
    - a. Large groups of synthesized insecticides
    - b. Stomach poisons; some contact toxicity
    - c. Hazardous to use
    - d. Examples: aldrin, dieldrin, chlordone, lindone toxophene, methorychlor, DDT
4. Phosphates
    - a. Generally more hazardous to use
    - b. Contact or stomach poison
    - c. Examples: parathion, malathion, systox, diazon, phosdrin
5. Nicotine compounds
    - a. One of the older insecticidal materials
    - b. Deadly stomach poison
    - c. Examples: nicotine sulfate (Black Leaf 40), nicotine bentonite

6. Oil sprays
    a. Used alone or as carriers of other insecticides
    b. Contact poison
    c. Petroleum oils the source
7. Mercury compounds
    a. Extremely toxic
    b. Stomach poison and repellant
    c. Examples: calomel, corrosive sublimate
8. Pyrethrum
    a. One of the oldest and safest materials
    b. Botanical insecticide; derived from genus chrysanthemum
    c. Contact poison
    d. Examples: pyrethrum, allethrin
9. Rotenone
    a. Botanical insecticide; derived from the derris or timbo plant
    b. Contact poison
    c. Toxic to animals; very toxic to fish
10. Phenothinzine and Piperozine
    a. To control internal parasites of livestock

Disease pests are controlled with bactericides and fungicides. There are no effective chemicals on the market for the control of plant viruses; but because certain viruses are transmitted by insects, insecticides that control insects indirectly can control these virus deseases. Fumigation of seed beds has reduced virus diseases in some plants, but it is questionable whether fumigation kills the virus organisms, kills the insects that transmit the virus, or causes the wounds which permitted the virus to attack. Sulfa drugs and antibiotics control certain viruses in livestock.

Plants of nearly all species are attacked by fungi. Seeds, roots, stems, leaves, flowers, and fruit parts--all are susceptible to fungi infection. Considerable progress has been made to control these diseases by the development of resistant varieties and improved cultural practices. Even so, the only practical means of controlling fungi on many plant species is by a sound fungicide program. As with other pesticides, the chemical to use and the time and method of application are critical for most fungi diseases. Frequently several applications of fungicides must be made.

There are five basic types of fungicides.

1. Sulfur and sulfur compounds
    a. Lime-sulfur is common
    b. Tent to be caustic to plants when
        1) Heavy applications are used
        2) Humidity is high
        3) Temperature is high
    c. Should be finely ground
2. Copper compounds
    a. Bordeaux mixture: one of the early fungicides
    b. Several other copper compounds
3. Formaldehyde
    a. Highly poisonous and irritating
    b. Used to treat seed and fumigate storage buildings and soil
4. Mercurial compounds
    a. Used for seed treatment
5. Organic compounds
    a. More effective than older materials

b. Most important group of present-day fungicides

c. Seven major groups of organic fungicides

d. Examples: ferbam, nabam, thiram, captan, gylodin, bioguin, choronil

Nematocides are used to control nematodes, a type of roundworm that generally live in the soil and cause damage to seeds, seedlings, roots, and occasionally to above-ground parts such as mum plants. Control is generally accomplished by fumigation. There are four basic materials used.

1. Methyl biomide
2. Chloropicrin
3. Dichloropropene
4. Ethylene dibromide

These materials are effective in controlling other pests at the same time they are controlling nematodes. Soil should have a temperature above 55°F. and good tilth at time of fumigation.

Pesticides are available in three basic physical forms--solid, liquid, and gas. Each has specific purposes, requires different application methods, and has specific advantages and disadvantages.

There are different forms of pesticides available as solids.

1. Dust, the common type of solid pesticide, has the following characteristics:
    a. Lighter than liquids
    b. Less work in preparation for application
    c. Difficulty in obtaining even application
    d. May lose effectiveness faster than sprays
    e. Impossibility of manufacturing certain pesticides (example, oils)

f. Danger of dust and vapor drift

g. Examples of the use of dust

1) Seed treatment to control fungus
2) Seed flats to control damping off
3) Vegetables and fruit dusted by airplane
4) Power dusters mounted on tractors to dust fruit trees
5) Hand dusters for home gardeners, some with CO_2 rechangeable
6) Dusting livestock for mites, lice, grubs, and other pests
7) Aerosol bombs for moth-proofing

2. Granules: a solid type pesticide

a. Small, free-flowing particles

b. Often mixed or combined with a carrier to provide enough bulk for even distribution

c. Applied by hand or mechanical spreaders

d. Applied as granules; no water needed

e. Fall or roll off leaves, preventing plant injury

f. Difficult to apply as uniformly as sprays

g. Examples of the use of granules

1) Insecticides used to control soil root worms
2) Systemic herbicides applied to soils
3) Insecticides that catch in corn whorls for corn borer control

3. Baits: grain mixtures, pellets, cubes

a. Various solid forms; not dusts or granules

b. Placed by hand where pests are located

c. May be used with bait boxes

d. Act as stomach poisons

Liquid materials are the most common form of pesticides. These materials are available in the following forms:

1. Wettable powders
    a. Sold as powders or dusts
    b. Mixed with water for application
    c. Indissoluble powders; stay in suspension
    d. Agitation required with some to maintain suspension
    e. Improper suspension can cause
        1) Nozzle clogging
        2) Uneven application
    f. Suspension partially maintained by wetting agents
    g. Many available as wettable powders
2. Emulsions
    a. Oil base or oil-like pesticides
    b. Mixed with water for application
    c. One liquid mixed in another, each maintaining its own identity
    d. May require agitation to prevent separation
    e. Generally has a "milky" color
    f. Suspension facilitated by emulsifying agents
3. Salts
    a. Sold as dry materials; dissolve in water
    b. Become homogeneous mixture of the water and salt
    c. Clear spray; may be colored, not cloudy
    d. Salt inseparable from water by mechanical means
    e. Assurance of uniform spray

4. Solutions
    a. Sold as clear liquids; may be colored
    b. Become homogeneous mixture with water
    c. Inseparable materials
    d. Assurance of uniform spray

Some types of pesticides are sold as gases, and are used as fumigants to control nearly all types of pests. Certain solid and liquid materials also vaporize and are used as fumigates.

Several factors influence the time to apply chemical pesticides. Under conditions when these factors tend to conflict with each other, judgment is needed to determine the most appropriate time to apply them. Factors governing timeliness of application are

1. Based on pest prevention rather than cure
2. Applied before the pest can do damage
3. Residue remains on or in edible products
    a. Chemical residue may be harmful to
        1) Humans
        2) Animals
        3) Subsequent crops
        4) Beneficial flora
    b. Residue must be removed or destroyed in processing.
4. They should be applied when the pest is most susceptible
5. They should be applied at a time least damaging to other plants and animals
6. They should be applied at a time when least damage will result to beneficial organisms or to the environment

In the 1952 U. S. Department of Agriculture Yearbook, the function of a sprayer is defined in the following manner:

> The main function of a sprayer is to break the liquid into droplets of effective size and distribute them uniformly over the surface or space to be protected. Another function is to regulate the amount of insecticide to avoid excessive application that might prove harmful or wasteful.

Materials used in insecticide, fungicide, herbicide, and defoliant sprays usually fall into three groups.

1. Inorganic compounds
2. Organic compounds
3. Oils

Several types of power sprayers have been developed to apply these sprays. The National Sprayer and Duster Association classified them in the following manner:

1. Hydraulic
    a. Multiple-purpose
    b. Small general use
    c. High-pressure, high volume
    d. Low-pressure, low volume
    e. Self-propelled, high clearance
2. Hydro-pneumatic
3. Blower
4. Aerosol

The most powerful sprayers are the hydraulic sprayers. The pressure created by the pump forces the liquid through the nozzle, which breaks the liquid into small droplets.

The typical hydraulic sprayer is made up of the following parts:

1. Pump
2. Tank
3. Agitator
4. Sprayer framework
5. Combined pressure regulator and relief valve
6. Pressure gauge
7. Strainers
8. Screen
9. Control valves
10. Piping and fittings
11. Distribution system
12. Power source
    (See diagram in Farm Machinery and Equipment, p. 242.)

In the main, positive displacement pumps are used on most hydraulic sprayers. The speed at which these pumps operate determines their discharge capacity. The following types of pumps are used on hydraulic sprayers:

1. Reciprocating
2. Piston
3. Plunger
4. Rotary
5. Diaphragm

Nozzles break the spray liquid into the desired size of droplets. Several types of nozzles made by manufacturers are designed for applying certain types of sprays and making certain application patterns. Three principle application patterns are used to apply sprays.

1. Hollow cone
2. Solid cone
3. Flat-fan

The selection of the proper nozzle should be based on the following factors:

1. Type of spray job
2. Amount of spray to be applied per acre
3. Row spacing and the number of nozzles used per row
4. Nozzle spacing if complete coverage is desired
5. Spray pattern desired
6. Approximate speed of travel
7. Approximate pressure to be used in spraying

The arrangement of the nozzles can be altered by using pendents, nozzle drops, or drop extensions. These arrangements are described in Farm Machinery and Equipment, pp. 246-247.

Hydro-pneumatic sprayers do not have a pump. The spray liquid is carried in a pressure tank and the spraying pressure is developed by means of an engine-powered air compressor.

Blower sprayers are a comparatively new type sprayer. They are used for treating large acreages of fruit trees, vegetables, and certain other crops. These machines operate in the following manner: a blast of air carries the chemical from the machine to the foliage to be treated; the spray liquid is forced under low pressure into the airstream in small droplets by a group of nozzles on shear plates. (See Farm Machinery and Equipment, p. 253, for example.)

The amount of spray applied to a given area depends on three factors.

1. Forward speed of the sprayer
2. Number of nozzles
3. Rate of discharge of spray

As a sprayer is made ready for use under field conditions, it should be checked for correct rate of application. The operation is called calibration. The essential steps in calibrating sprayers are presented in Farm Machinery and Equipment, pp. 255-258.

Suggested Teaching-Learning Activities

1. Collect samples or have the students collect samples of the various forms of pesticides, dusts, granules, wettable powders, salts, oils, solutions, gases, and other types of pesticides. Suggest that less toxic materials be collected and that they be kept in safe storage.
2. Demonstrate in small amounts the mixing of various pesticides to show emulsions, solutions, and dissolving of salts. Point out the cloudy or milky emulsions and clear solutions. Demonstrate the effectiveness of wetting agents and emulsifiers.
3. Demonstrate the need for good timing in using herbicides for weed control. With the same material at the same rate, treat an area of weeds at emergence, at rapid growth stage, and at full bloom, and note the variation in effectiveness.
4. Through field trips and laboratory or field demonstrations, acquaint the students with common pesticide applicators used in your area.
5. Develop several problems with common pesticide products used in your area to give the students experience in calculating active ingredients and amount to apply per acre.
6. Give students the opportunity to clean dust, granular, and spray applicators properly.

7. Arrange a field trip(s) so that students may observe a commercial operation in application of pesticides.

8. Bring several types of sprayers before the class. Disassemble each simultaneously, pointing out the differences in construction. Have students study these differences and learn the parts of each type.

9. Under field conditions, demonstrate proper and improper adjustment of several types of sprayers.

10. Bring to class examples of each type of spray discussed in the content. Have students compare them.

11. Bring to the class sprayers in need of adjustment and repair of as many types as possible. Follow the procedure below when making the needed adjustments and repairs.

    a. Operate the machine in the field to discover any malfunctions in operation.

    b. Inspect the machine, noting worn and broken parts and parts that are out of line or adjustment.

    c. Following the operator's and service manuals, make the necessary repairs and adjustments.

    d. Lubricate the machine for field operation.

    e. Calibrate the machine.

    f. Test the machine in the field and make any adjustments necessary for proper operation.

Suggested Instructional Materials and References

Instructional materials

1. Machines for disassembly

2. Machines for use in demonstrating proper and improper field operation

References

1. Farm Machinery and Equipment, pp. 237-268.
2. Machines for Power Farming, pp. 398-424.
3. Operator's manuals
4. Service manuals

Suggested Occupational Experience

Have students adjust, repair, and calibrate sprayers at the local agricultural machinery dealership, following the procedure outlined in the teaching-learning activities.

IX. To (1) identify the parts of fertilizer applicating machines and how they function and (2) adjust and repair these machines

Teacher Preparation

Subject Matter Content

In order to understand fertilizer machines, the functions of their parts and make proper adjustments and repairs on these machines, an agricultural machinery service employee must be familiar with the types of fertilizer these machines are designed to apply to the soil.

There are three groups of soil nutrients: (1) primary, (2) secondary, and (3) micro or trace nutrients.

1. Primary plant nutrients (N, P_2O_5, K_2O). They are called primary because soils normally cannot provide them in the large amounts needed for healthy growth.
    a. Nitrogen (N)
        1) Gives dark green color to plants
        2) Promotes rapid growth
        3) Improves quality and protein content

b. Phosphorus (P) is expressed in fertilizer as available phosphate (P_2O_5).

    1) Stimulates early root development and growth
    2) Hastens maturity, promotes seed production
    3) Improves winter hardiness of legumes

c. Potassium (K) is stated in terms of potash (K_2O).

    1) Increases vigor and disease resistance
    2) Aids in food formation
    3) Stiffens straw and stalk parts

2. Secondary plant nutrients (Ca, Mg, S) are required by plants in substantial quantities. Soils are adequate in some areas and lacking in others.

    a. Calcium (Ca)

        1) Promotes early root formation and growth
        2) Encourages seed production
        3) Neutralizes poisons produced in plants

    b. Magnesium (Mg)

        1) Maintain chlorophyll and photosynthesis
        2) Formation of sugar, fats, and oils
        3) Plays a part in translocating food within the plant

    c. Sulfur (S)

        1) Is essential ingredient in protein
        2) Maintain dark green color
        3) Promotes module formation on legumes

3. Micro-nutrients (B, Cu, Fe, Mn, Mo, Zn, Cl) are required by plants in trace amounts. Sandy soils, peats and mucks are most often deficient in them.

    a. Boron (B)

        1) Increases yield and quality
        2) Is associated with calcium utilization

- b. Copper (Cu)
    - 1) Important in citrus and vegetable production
- c. Iron (Fe)
    - 1) Is associated with formation of chlorophyll
    - 2) Aids in plant respiration
- d. Manganese (Mn)
    - 1) Accelerates germination and maturity
    - 2) Aids in photosynthesis
- e. Molybdenum (MO)
    - 1) Is used by legumes in nitrogen fixation
- f. Zinc (Zn)
    - 1) Is necessary for chlorophyll formation
    - 2) Is vital as a growth regulator
- g. Chlorine (Cl)
    - 1) Functions not understood

Excessive amounts of minor nutrients can be as harmful as inadequate amounts. Micro-nutrients are usually deficient in the following types of soil.

1. Muck and peat soils
    - a. Boron
    - b. Copper
2. Alkaline soils
    - a. Iron
    - b. Manganese
    - c. Zinc
3. Acid soils
    - a. Molybdenum

The three major plant foods are nitrogen, phosphorus, and potassium.

Nitrogen is an abundant, inert gas found in the atmosphere. Before it can be used by most plants, it must be combined with oxygen or hydrgoen.

Three groups of nitrogen-carrying materials are used in the fertilizer industry.

1. Inorganic nitrogenous materials
    - a. Sulfate of ammonia
    - b. Anhydrous and liquid ammonia
    - c. Nitrate of soda
    - d. Ammonium nitrate
    - e. Ammonium phosphate
    - f. Calcium nitrate
    - g. Nitric phosphates
    - h. Nitrate of potash
2. Natural organic nitrogen materials
    - a. Plant and animal by-products
    - b. Guano
3. Synthetic organic nitrogen materials
    - a. Urea
    - b. Calcium cyanamid

When making adjustments on fertilizer machines either in the agricultural machinery service department or in the field, it is important that the service employer understand the nature of these fertilizers and their methods of application.

1. Anhydrous ammonia

   a. Toxic, hazardous gas, difficult to store and handle

      1) Can cause serious burns
      2) Can cause death by asphyxiation
      3) Is flammable and explosive
      4) Is stored in steel tanks with a strength of 265 pounds per square inch

   b. Anhydrous ammonia

      1) Is 99.5% ammonia, 81.8% nitrogen (82%)
      2) Is 5% water
      3) Weighs 5.14 pounds at 60°F.

   c. Application

      1) Applied "into" soil at a depth of 4-8 inches depending on soil conditions
      2) Is applied under pressure
      3) Rate of application controlled by valves
      4) Requires special handling and application equipment

   d. Retention and behavior in soil

      1) Little or no loss under normal soil conditions
      2) Some losses in exceptionally sandy, dry, or wet and cloddy soils
      3) Retention of ammonia on clay and organic particles in the soil
      4) May make clay stiffer and more compact, but probably not enough to be significant
      5) Increases pH in zone of application, improves solubility of phosphate slightly
      6) Less leaching than with nitrates

2. Ammonium nitrate

   a. Solid chemical compound containing 33.5% nitrogen

      1) Water soluble, quick acting
      2) Approximately one-half of the nitrogen is in nitrate form and one-half in the ammonia form

b. Has an affinity for moisture, will cake

   1) Has protective covering to decrease absorption of water
   2) Store in water proof bags

c. Safety precautions with ammonium nitrate

   1) Don't smoke or expose to open flames
   2) Keep away from steam pipes, electrical wiring, and combustible materials
   3) Store in well ventilated building
   4) Clean up and discard spilled material
   5) Promptly destroy empty bags

d. Application with a dry fertilizer applicator, surface or subsurface

e. Retention and behavior in soil

   1) Rapid solubility, rapid uptake by plants
   2) Possible leaching of nitrate portion
   3) Reduces pH slightly

3. Nitrogen solutions

   a. Nitrogen materials that dissolve in water

      1) Ammonium nitrate
      2) Urea
      3) Ammonia

   b. Low pressure and non-pressure type

      1) Free ammonia in low pressure type
      2) Crystallization (salting out) problem in cool weather (See table)

Total Nitrogen Available in Solution	Composition of Liquid Nitrogen by Percent				Total Composition by Percent	Crystallization Temperature (°F)
	Free Ammonia	Ammonium Nitrate	Urea	Water		
41.0%	22.2	65.0		12.8	100	21°
41.0	19.0	58.0	11.0	12.0	100	7°
32.0		44.3	35.4	20.3	100	32°
20.0		57.3		42.7	100	42°
20.0	24.3			75.7	100	-70°

c. Storage and application

1) Non-pressure, no special storage problems
2) Low pressure, in sealed tank with pressure gauge
3) Corrosive to steel; aluminum or fiber glass tanks recommended
4) Possible to apply certain non-pressure fertilizers to soil surface
5) Necessity of putting low-pressure fertilizers into the ground

4. Ammonium sulfate

a. Dry material containing 21% nitrogen, 24% sulfur

b. Does not absorb water or cake

c. Leaves acid residue, lowering soil pH

d. Should be applied to land in bands or broadcast, surface or subsurface

5. Ammonium phosphates

a. Types

1) Mono-ammonium phosphate containing 11 to 16% nitrogen
2) Di-ammonium phosphate containing 16 to 21% nitrogen

  - b. Dry material fertilizers, well suited for top dressing grasses and legumes
  - c. Lowers the soil pH

6. Aqua ammonia
  - a. 20-26% nitrogen, ammonia dissolved in water
  - b. Similar to anhydrous ammonia, less hazardous
  - c. Must be pumped, does not supply its own pressure
  - d. Is applied two or more inches deep with special equipment

7. Sodium nitrate
  - a. 16% nitrogen, mined or manufactured
  - b. Dry material, applied in bands or broadcast, surface or subsurface
  - c. Rapidly available, water soluble
  - d. Slight increase in soil pH
  - e. Absorbs water; should be stored in dry place in water-proof bags, will cake
  - f. Should not be used on heavy clay soils possessing a high pH; may produce a "black alkali" condition

8. Calcium nitrate
  - a. 16% nitrogen, dry material
  - b. Absorbs water, store in dry place in water-proof bags
  - c. Slight increase in soil pH

9. Nitric phosphates
  - a. 12-20% dry material

10. Natural organic nitrogen materials
    - a. Largely insoluble in water, 2-9% nitrogen
    - b. Nitrogen released slowly as organic matter decomposes
    - c. Favored in some lawn fertilizers
    - d. No danger of leaching
    - e. Relatively high priced
11. Urea
    - a. Dry material, containing 46% nitrogen
    - b. Water soluble, favored for foliar spraying
    - c. Urea combined with formaldehyde is slow releasing (urea-form)
12. Cyanamid
    - a. Dry material, 21-22% nitrogen
    - b. Water soluble

Characteristics of the major phosphorous fertilizers and their use must be understood. Most of the phosphorus in soils is in a comparatively insoluble form. Even soluble phosphates are often transformed into less soluble phosphates called "fixed" in many soils. The type of phosphorus to use and method of application are important factors to consider. In general, more phosphorous fertilizer should be added than is required by the growing crop. However, this additional phosphorus is held in the soil for succeeding crops.

1. Rock phosphate
    - a. Relatively insoluble, slowly available to crops
    - b. Can raise the phosphorus level in soil
    - c. Effectiveness improved by fine grinding
    - d. Best results on acid soils high in organic matter

2. Superphosphate
    a. Most widely used source of phosphorus
    b. Does not change pH of soil
    c. Phosphorus is soluble in soils
    d. Two types of superphosphate
        1) Single strength, 18-20 percent phosphoric oxide
        2) Triple superphosphate, 40-50 percent phosphoric oxide; often called double, treble, or concentrated superphosphate
3. Ammonium phosphates
    a. Contain nitrogen and 15-33 percent phosphate
    b. Phosphorus nearly all water soluble
    c. Commonly used in complete fertilizers
    d. Common types
        1) Mono-ammonium phosphate--48%, trade name Ammo-phos A
        2) Di-ammonium phosphate--48-53%, trade name Ammo-phos B
        3) Ammoniated superphosphate--18-20%
        4) Ammonium phosphate-nitrate--15%
        5) Ammonium phosphate sulfate--20-39%
4. Nitric phosphates
    a. Contain nitrogen plus 10-22 percent phosphate
    b. Relatively new material, increase in use
5. Liquid phosphoric acid
    a. As indicated, a liquid, 52-54% phosphate
    b. Used in irrigation water or directly sprayed on soil
    c. Lowers pH on alkaline soils
    d. Superphosphoric acid, 75% phosphate

   e. More costly than other recommended phosphorous fertilizers

   f. Strong acid; should be handled with care

6. Colloidal phosphate

   a. Trade mark for a low-grade rock phosphate or phosphatic clay

   b. Relatively insoluble, seldom recommended

7. Calcium metaphosphate

   a. Is 62-65 percent available phosphate in acidic soils

   b. Not recommended on alkaline soils; is insoluble

Other phosphorous fertilizers are available, but in limited or local areas. Their value should be determined by their solubility and relative price as compared to the more common, recommended phosphate fertilizers.

The characteristics of the various potash materials in soil fertility are similar.

1. Muriate of potash (potassium chloride)

   a. 50-62% potash, water soluble

   b. Most common source of potash fertilizer

2. Sulfate of potash (potassium sulfate)

   a. Contains less chlorine than muriate and is favored by tobacco growers

   b. 50% potash, water soluble

3. Nitrate of potash (potassium nitrate)

   a. Contains nitrogen plus 45% potash

   b. Little commercial importance, imported from Chile

4. Potassium-magnesium sulfate
    a. Contains magnesium and 22% potash, both water soluble
    b. Sold under trade name "Sulpo-mag"

Soils contain large quantities of potassium, but it is largely unavailable to plant growth. Liming increases the availability of potassium and also reduces potassium leaching.

Fertilizers are sold in three forms--dry, liquid, and gaseous. Anhydrous ammonia is the only gaseous fertilizer. They may be straight materials, containing only one major nutrient, mixed fertilizers containing all three major nutrients of nitrogen, phosphorus and potassium. Over 60% of all fertilizers sold are mixed fertilizers. Dry fertilizers can be granulated, mixed, chemically blended, or made as a combination of the three.

1. Granulated fertilizers are converted into granules of uniform size, each containing the ingredients in the same proportion. This is called pelleting.
2. Chemically blended materials chemically react to form materials of homogenous composition. These are then made into granules.

Fertilizers differ in their grade analysis. The common classifications are

1. Ordinary grade, containing a total value of less than 20 percent nitrogen, phosphate, and potash
2. High grade, containing 20-30 percent total plant food, such as 6-12-12
3. Concentrated grade, containing over 30 percent total nutrients, such as 12-12-12

The trend is to concentrated grade fertilizers for several reasons.

1. Economical transportation, handling, bagging, and storage
2. Reduced salt toxicity and less material needed to supply the needed amount of plant food

Lower grade fertilizers, however, generally contain more secondary and trace-elements and have a better physical condition. Concentrated liquid fertilizers are more likely to crystalize or "salt out."

As the agricultural machinery service employee makes adjustments and repairs on fertilizing machines, he will be confronted with many questions concerning the content of fertilizers. He should understand the composition of commercial fertilizer well enough to answer these questions. He should know

1. The meaning of the numbers on a bag of fertilizer
2. Fertilizer ratios
3. How to compare values of various fertilizers
4. How to change plant food percent to elemental percent

The numbers on the bag refer to the percent of the three primary plant nutrients--nitrogen, phosphorus, and potassium--in that order in the bag, and is the guaranteed analysis. A 6-24-12 fertilizer contains

1. 6 percent nitrogen (N)
2. 24 percent available phosphoric oxide (P_2O_5)
3. 12 percent soluble potash (K_2O)

This would be a 42 unit (6 + 24 + 12) fertilizer and has a 1-4-2 ratio, determined by dividing all the numbers by the smallest. A 4-16-8 fertilizer would have the same 1-4-2 ratio but would contain 28 units of fertilizer. Assuming a customer wanted to apply 300 pounds of 3-16-8 per acre, but found that it was not available, 200 pounds of 6-24-12 would supply the same amount of primary nutrients; 12 pounds of nitrogen, 48 pounds of phosphoric oxide, and 24 pounds of potash.

Mixed fertilizers often contain secondary or trace elements in addition to the primary elements. When a certain level is guaranteed, the amount must be stated on the bag. A popular grade in the orange country is 4-6-8-3-1-1½, with the last three numbers standing for magnesium, manganese, and copper. Where the amount is not guaranteed, just the fact that the nutrient is added is sufficient. In certain areas 0-15-45 B is a popular alfalfa fertilizer, with the B indicating that boron is added. Other fertilizers are sold as trace element fertilizers as "5-20-20 with trace elements added."

The principal ratios and grades of mixed fertilizer sold in the United States are listed below. These make up over seventy percent of the mixed fertilizer tonnage used annually.

Ratio	Grades
1-2-2	5-10-10; 6-12-12; 8-16-16
1-4-4	4-16-16; 3-12-12; 5-20-20; 6-24-24
1-1-1	12-12-12; 10-10-10; 8-8-8
1-2-3	5-10-15; 4-8-12
1-2-1	5-10-5; 10-20-10
1-4-2	6-24-12
1-3-3	3-9-9
0-1-1	0-20-20
0-1-3	0-10-30; 0-15-45; 0-12-36

Several types of machines have been developed to apply fertilizers.

1. Granular
2. Gas and liquid

Granular fertilizer applicators are manufactured in a variety of types. These include

1. Attachments for row-crop planters
2. Attachments for grain drills
3. Attachments for cultivators
4. Attachments for chisel plows
5. Machines that broadcast fertilizer

Fertilizer attachments used on a row-crop planter are of two types, based on the type of feeding mechanism.

1. Star or spur wheel type
2. Plow type
   (See Machines for Power Farming, pp. 340-341.)

A separate compartment for applying fertilizer is used on grain drills. The fertilizer granules are placed in a hopper similar to the seed hopper. The star finger feed wheels, driven by two bevel gears, moves the fertilizer granules to a special shed at the front of the hopper. This shed is made up of a series of removable back plates that cover the fertilizer drop openings. (See Machines for Power Farming, pp. 363-365.)

On cultivators and chisel plows, the fertilizer granules are fed into a metering device from a hopper similar to a row-crop planter hopper. From the metering device, the fertilizer is dropped into feeder tubes that place the fertilizer in the furrow left by the cultivator or chisel shovels.

The end gate trailing type of fertilizer distributor is the most commonly used broadcast applicator. The fertilizer granules are placed in ahopper where it is fed into the fertilizer drop openings by a rotor in the bottom of the hopper. An agitator is used to keep the fertilizer from bridging in the hopper and to break down any lumps or clods that may be in the fertilizer. Some broadcasters use a scattering board to broadcast the fertilizer more thoroughly. This board is located directly below the fertilizer drop openings in the bottom of the hopper. (See Machines for Power Farming, pp. 283-286.)

With the advent of gas and liquid fertilizers came the development of new and different types of fertilizer applicators. These applicators force the gas or liquid into the soil under high pressure. They are equipped with a tank, pressure hoses, carrying tubes, and shovels for opening the soil. The carrying tubes are connected to a small pipe welded to the rear side of the chisel knives or shovels. As the shovels enter and penetrate the soil to the desired depth, the gas or liquid fertilizer is forced out through the pipe into the soil.

Gas and liquid fertilizer applicators can be calibrated to control the amount of fertilizer being applied. This procedure is outlined and discussed in Farm Machinery and Equipment, pp. 284-286.

Suggested Teaching-Learning Activities

1. Using fertilizer applicators discussed in the subject matter content, demonstrate how each machine works in the soil. After demonstrating proper operation of each type of machine, throw the machines out of adjustment and have the students observe the results.

2. Have students disassemble each type of fertilizer-applicator discussed in the content and learn their parts. Point out to the students the materials used in constructing each part and the function each part plays in the total operation of the machine.

3. Bring to the class fertilizer applicator machines that are in need of adjustment and repair of each type discussed in the subject matter content. Follow the procedure below when making the needed adjustments and repairs.

    a. Operate the machine in the field, noting any malfunctions in operation.

    b. Inspect the machine, noting worn and broken parts and parts that are out of line or adjustment.

    c. Following the operator's and manufacturers manuals, make the necessary repairs and adjustments.

    d. Lubricate the machine for field operation.

    e. Test the machine in the field and make any adjustments necessary for proper operation.

Suggested Instructional Materials and References

Instructional materials

1. Machines for disassembly

2. Machines for use in demonstrating proper and improper field operation

References

1. Machines for Power Farming

2. Farm Machinery and Equipment

3. Operator's manuals

4. Manufacturer's service manuals

Suggested Occupational Experience

Have students adjust, repair, and lubricate fertilizer applicators at the local agricultural machinery dealership under the supervision of a skilled mechanic, following the procedure outlined in the teaching-learning activities.

X. To prepare and paint tillage, planting, spraying, and fertilizing machines after they have been repaired

Teacher Preparation

Subject Matter Content

If the person being taught this module has not been taught the competency on preparing and painting the tractor in the module on "Tractor Repair," he should be taught that competency at this time. The procedures to be followed when painting these machines are the same as those to follow when painting a tractor.

Suggestions for Evaluating Educational Outcomes of the Module

The following criteria should be used to evaluate the educational outcome of this module.

1. Attentiveness in class and participation in laboratory activities

2. The ability of the student to use the operator's and service manuals

3. The ability of the student to perform the repair and adjustment activities on machines. As a final outcome it is suggested that each student completely recondition a machine in need of repairs and adjustment.

4. Employers evaluation of the ability of the student to adjust, repair, and service machines in his dealership.

Sources of Suggested Instructional Materials and References

1. Knuti, Korpi, and Hide. Profitable Soil Management. Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1962.

2. Smith, N. P. Farm Machinery and Equipment, Fifth Edition. New York: McGraw-Hill, 1964. Price: $10.50.

3. Stone, A. A. and Gulvin, H. E. Machines for Power Farming. New York: John Wiley and Sons, Inc., 1957. Price: $5.95.

4. Operator's and service manuals from major line agricultural machinery manufacturers.

THE CENTER FOR RESEARCH AND LEADERSHIP DEVELOPMENT
IN VOCATIONAL AND TECHNICAL EDUCATION
THE OHIO STATE UNIVERSITY
980 KINNEAR ROAD
COLUMBUS, OHIO, 43212

INSTRUCTOR NOTE: As soon as you have completed teaching each module, please record your reaction on this form and return to the above address.

1. Instructor's Name______________________________

2. Name of school______________________State______________

3. Course outline used:
   - _____Agriculture Supply--Sales and Service Occupations
   - _____Ornamental Horticulture--Service Occupations
   - _____Agricultural Machinery--Service Occupations

4. Name of module evaluated in this report______________________

5. To what group (age and/or class description) was this material presented?____
____

6. How many students:
   - a) Were enrolled in class (total) ________
   - b) Participated in studying this module ________
   - c) Participated in a related occupational work experience program while you taught this module ________

7.

Actual time spent teaching module:		Recommended time if you were to teach the module again:
_____hours	Classroom Instruction	_____hours
_____hours	Laboratory Experience	_____hours
_____hours	Occupational Experience (Average time for each student participating)	_____hours
_____hours	Total time	_____hours

(RESPOND TO THE FOLLOWING STATEMENTS WITH A CHECK (✓) ALONG THE LINE TO INDICATE YOUR BEST ESTIMATE.)

	VERY APPROPRIATE . . . NOT APPROPRIATE
8. The suggested time allotments given with this module were:	|____.____.____.____.____|
9. The suggestions for introducing this module were:	|____.____.____.____.____|
10. The suggested competencies to be developed were:	|____.____.____.____.____|
11. For your particular class situation, the level of subject matter content was:	|____.____.____.____.____|
12. The Suggested Teaching-Learning Activities were:	|____.____.____.____.____|
13. The Suggested Instructional Materials and References were:	|____.____.____.____.____|
14. The Suggested Occupational Experiences were:	|____.____.____.____.____|

(OVER)

15. Was the subject matter content sufficiently detailed to enable you to develop the desired degree of competency in the student? Yes_____No_____
Comments:

16. Was the subject matter content directly related to the type of occupational experience the student received? Yes_____No_____
Comments:

17. List any subject matter items which should be added or deleted:

18. List any additional instructional materials and references which you used or think appropriate:

19. List any additional Teaching-Learning Activities which you feel were particularly successful:

20. List any additional Occupational Work Experiences you used or feel appropriate:

21. What do you see as the major strength of this module?

22. What do you see as the major weakness of this module?

23. Other comments concerning this module:

____________________ ____
(Date) (Instructor's Signature)

____
(School Address)